

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to the Department of Defense, Executive Services and Communications Directorate (0704-0188). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION.					
1. REPORT DATE (DD-MM-YYYY) 29-07-2014		2. REPORT TYPE Journal Article		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE Ocean Optics				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER 0602782N	
				5d. PROJECT NUMBER	
6. AUTHOR(S) Weilin Hou				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER 73-6604-04-5	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Research Laboratory Oceanography Division Stennis Space Center, MS 39529-5004				8. PERFORMING ORGANIZATION REPORT NUMBER NRL/JA/7330--14-2171	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Office of Naval Research One Liberty Center 875 North Randolph Street, Suite 1425 Arlington, VA 22203-1995				10. SPONSOR/MONITOR'S ACRONYM(S) ONR	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution is unlimited.					
20140805592					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT The sub-discipline of ocean optics is an exciting and equally challenging field, as the scattering and absorption agents in the water, and the water itself, severely limits that range of optical reach when compared to the in-air systems. Optical methods provide the only means to penetrate the ocean from space. In this section, we examine the latest development in underwater imaging, ocean color remote sensing and lidar, through measurements and models.					
15. SUBJECT TERMS Remote sensing, ocean optics, lidar, underwater imaging, underwater turbulence, optical turbulence					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT		18. NUMBER OF PAGES
a. REPORT	b. ABSTRACT	c. THIS PAGE	UU		1
Unclassified	Unclassified	Unclassified			19a. NAME OF RESPONSIBLE PERSON Weilin Hou
					19b. TELEPHONE NUMBER (Include area code) (228) 688-5257

## Ocean Optics

### Weilin Hou

Ocean Hydro Optics, Sensors and Systems Section  
U.S. Naval Research Laboratory  
1009 Balch Boulevard  
Stennis Space Center, Mississippi 39529  
E-mail: Weilin.Hou@nrlssc.navy.mil

The subdiscipline of ocean optics is an exciting and equally challenging field, as the scattering and absorption agents in the water, and the water itself, severely limit the range of optical reach when compared to in-air systems. A typical range reduction factor of 1000:1 is often used as a crude estimation of optical range in water. Extending beyond this range often requires dedicated design and postprocessing systems. The same can be said of the preservation of spatial resolution under these conditions.

Several papers in this special section take on these challenges directly in terms of enhancing underwater imaging and communication system performance. Different approaches have been applied, including using RF modulated pulses to better eliminate scattered photons (S. O'Connor et al.); enhanced optical sensing range accuracy in the meantime in a hybrid approach (R. W. Lee et al.); better suppression of forward-scattered photons with high-frequency modulation (B. Cochenour et al.); and a new class of laser line-scanning system taking advantage of compressive sensing imaging techniques (B. Ouyang et al.). Modeling is key in system design and performance estimation. A physical simulator for optical communication systems is a great example of that (F. R. Dalgleish et al.).

Ocean color remote sensing provides synoptic views of the near-surface returns from the ocean, and can provide much-needed knowledge in monitoring coastal environments (C. Hu et al.). However, due to the passive nature of the approach, it is prone to the effects of other environmental forcing besides the desired components, such as aerosol contributions, which can attribute up to 90% of the detected signals at the sensor level for the space-borne platforms. Other factors such as surface specular reflectance or location of the sun can also pose challenges in data retrieval.

Subsurface irradiance variations induced by the sea surface can be problematic, especially when the sampling footprint is small, such as those related to calibration/validation efforts. The effect has been simulated using a Monte Carlo method (Z. Xu and D. K. P. Yue). Active sensing by the means of lidar eliminates many of the issues, however. These are discussed in depth in the review paper by J. H. Churnside, along with various designs and property retrieval algorithms. Lidar provides the only means of penetration into the ocean subsurface layers, which is critical in a myriad of applications ranging from ocean sensing and modeling, to momentous exchange between the atmosphere and the ocean and related CO<sub>2</sub> distributions which influence global climate change, to defense applications in mine countermeasures and antisubmarine warfare. It is exciting to see that the Brillouin lidar technique in sensing the subsurface temperature and sound velocity has matured enough to provide the needed accuracy on the order of 0.07 degrees (A. Rudolf and T. Walther).

Topics in the ocean optics field most definitely involve multiple disciplines, due to the nature of the subject and its spatial as well as temporal variability under observation. It is my hope that highlighting some of the recent advances from this field will help to excite new and renewed interest in this challenging area.

**Weilin "Will" Hou** is an oceanographer at the U. S. Naval Research Laboratory and manages the Hydro Optics, Sensors and Systems Section. He received his PhD from the College of Marine Science, University of South Florida in 1997. His research interests include ocean optics, underwater imaging, optical turbulence, remote sensing including LIDAR, numerical simulation, data management, instrumentation, and platforms, including unmanned aerial and underwater vehicles. He organizes the Ocean Sensing and Monitoring conference as part of the SPIE Defense and Security Symposium, and he teaches a short course on the related topics. He is a Fellow of SPIE.